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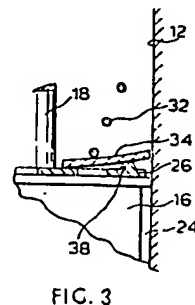
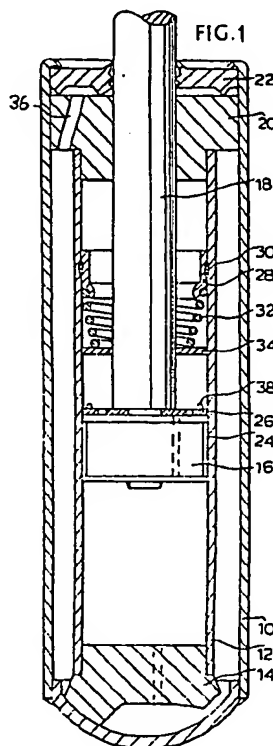
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**(54) A hydraulic shock absorber with rebound stop**

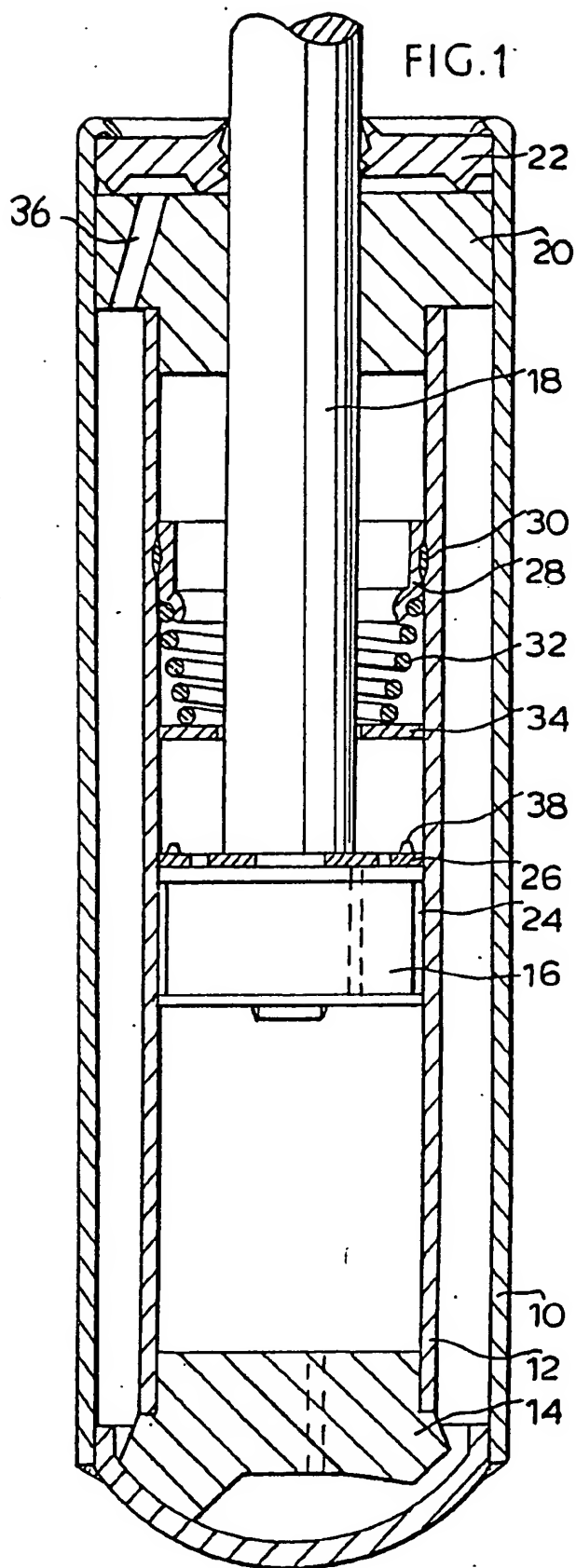
(57) A hydraulic shock absorber has a hydraulic rebound stop. A stop plate 34 supported in the cylinder 12 by a spring 32 acts to obstruct the intake apertures to the rebound valve in the piston 16, to reduce hydraulic flow through the piston. The surface of the piston facing the plate 34 has an annular ridge 38, and the spring 32 bears on the plate 34 (on the opposite side to the ridge 38) around an annulus of different radius so that when the spring 32 is compressed, the plate 34 is distorted (see Fig. 3) to increase the obstruction afforded to the rebound valve intake apertures. The intake apertures and the ridge 38 are actually formed in/on a plate 26 attached to the piston.



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FIG.1



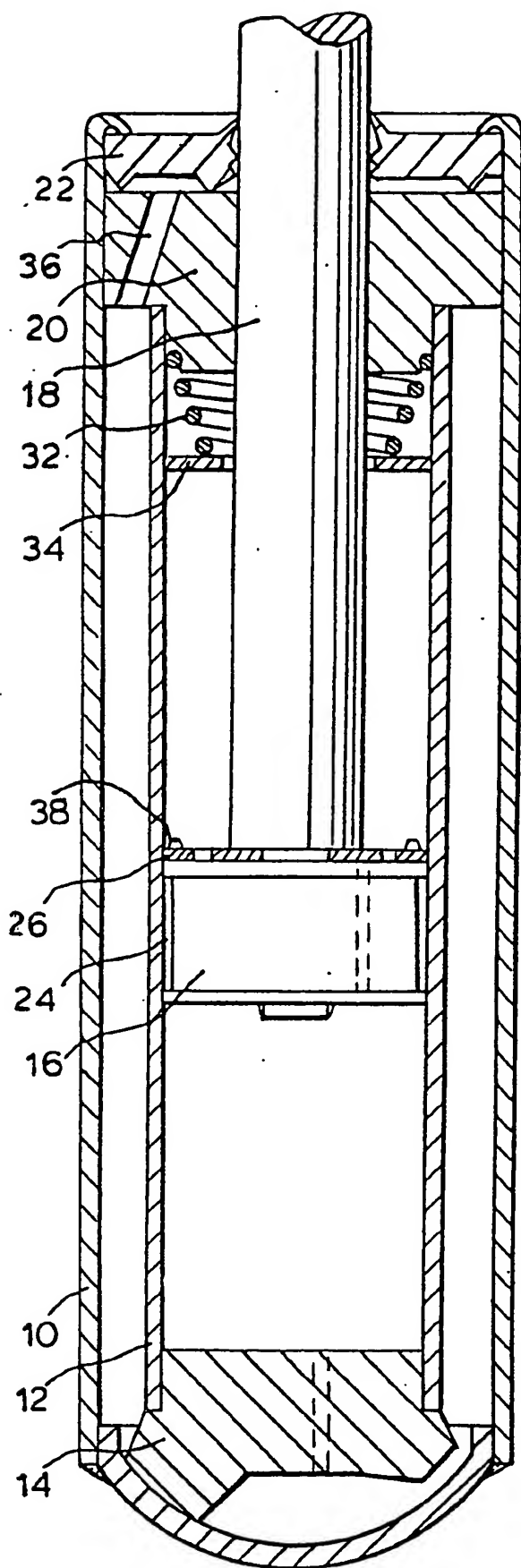


FIG. 2

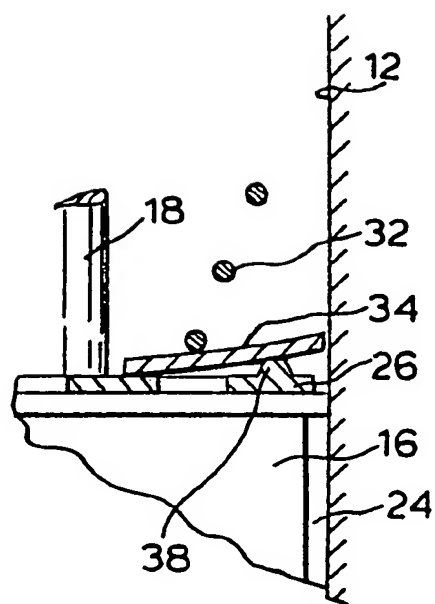


FIG. 3



## SPECIFICATION

## A Hydraulic Shock Absorber

This invention relates to a hydraulic shock absorber with a hydraulic rebound stop. The hydraulic rebound stop acts to cushion the impact when the shock absorber reaches the end of its rebound travel.

Hydraulic shock absorbers conventionally have a fixed rebound stop, which may have an elastic cushion fitted to it. This arrangement is not very satisfactory in that a considerable jar can be imparted to the vehicle body when the end of the rebound travel is reached and this is undesirable. The problem arises particularly in small modern cars, where packaging considerations may dictate a short stroke length for the shock absorbers.

According to the present invention, there is provided a hydraulic shock absorber with a piston working in a cylinder, and a hydraulic rebound stop mechanism for limiting rebound travel of the piston, the mechanism comprising an annular rebound stop plate supported by a compression spring against the cylinder, the outer periphery of the plate being a close fit with the cylinder wall and the internal periphery of the plate being spaced from the piston rod, a piston travel limit plate secured to the piston, the piston travel limit plate having fluid flow apertures therethrough, and an annular ridge between the piston travel limit plate and the rebound stop plate, the stop plate and limit plate cooperating at one end of the piston travel in the cylinder so that the stop plate obstructs the fluid flow apertures in the limit plate, with the compression spring supporting the rebound stop plate around an annulus of different radius from that of the annular ridge between the piston travel limit plate and the rebound stop plate.

With this type of rebound stop mechanism, the stop function is achieved by progressively throttling apertures through which the hydraulic fluid flows.

The annular ridge is preferably on the piston travel limit plate.

Since the piston travel limit plate is mounted on the piston, its presence in no way restricts the normal working movement of the piston in the cylinder.

The annular rebound stop plate can be made of a plastics material, for example nylon.

The invention will now be further described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a section through a first embodiment of a shock absorber in accordance with the invention;

Figure 2 is a cross section through a second embodiment of a shock absorber in accordance with the invention;

Figure 3 is an enlarged detail illustrating the positions taken up by the rebound stop plate and the piston travel limit plate at the end of the rebound travel of the shock absorber.

Figure 4 is a cross section through a third embodiment of a shock absorber in accordance with the invention.

Figure 1 shows a shock absorber having an outer

cylinder 10 and a working cylinder 12 within the outer cylinder. A base or compression valve 14 controls movement of hydraulic fluid between the outer cylinder and the working cylinder. A piston 16 is mounted at the end of a piston rod 18 and slides in the working cylinder 12.

The piston rod moves in a piston rod guide 20, and a fluid seal is formed by the sealing member 22.

The piston 16 incorporates rebound valving which damps rebound movement of the piston within the cylinder and the piston has a liner or ring 24. The upper surface of the piston forms a piston travel limit plate 26. This plate has apertures which allow fluid to enter the piston 16 and to pass through the rebound valving.

Within the working cylinder 12, and on the piston rod side of the piston 16 a rebound stop support 28 is fixed to the cylinder wall by means of a weld 30. A rebound stop compression spring 32 is located by the support 28, and a rebound stop plate 34 is positioned adjacent the free end of the spring. The rebound stop plate 34 can be of steel or can be of an elastic polymer, e.g. nylon, and should be a push fit inside the working cylinder, so that a seal is formed between the plate 34 and the cylinder wall. If the plate 34 is metal, it can be welded to the spring. If it is of nylon, it can be secured to the spring by integrally moulded clips. The spring can be clipped over the rebound stop support. The rebound stop assembly can thus be preassembled before being inserted and welded into the cylinder.

In operation, rebound movement is accommodated by upward movement of the piston 16 within the working chamber 12. This movement is damped by the rebound valving within the piston which restricts the flow of hydraulic fluid from the upper side of the piston to the lower side, and thus damps rebound movement. As the piston 16 reaches the end of its upward movement, the piston travel limit plate 26 comes into contact with the rebound stop limit plate 34. Contact is made between an annular ridge 38 on the plate 26, and the under surface of the plate 34.

Once this happens, the apertures in the limit plate 26 begin to be obscured and the hydraulic fluid above the piston at this stage can no longer flow freely through the rebound valving. The damping of the rebound movement is thus increased. As the piston moves a little further, against a high hydraulic load, the rebound stop spring 32 is compressed and causes the stop plate 34 to slide along the cylinder. As this happens, some hydraulic fluid will be forced out of the working cylinder between the piston rod 18 and the guide 20. This fluid passes into the outer cylinder 10 through a passage 36. At the same time, it should be noted that the rebound stop spring 32 is conical in form and acts on an annular portion of the stop plate 34 which is spaced from the working cylinder wall. The intake valve limit plate 26 has an annular ridge 38.

The main reason for the shape of the spring 32 and the presence of the ridge 38 is explained with reference to Figure 3. As the piston 16 approaches the rebound stop plate 34, the first contact is made

when the ridge 38 contacts the outer periphery of the plate 34. In this position, the flow of hydraulic fluid into the intake openings in the limit plate 26 is restricted, but not cut off. As the piston 16 moves further in the same direction, the plate 34 is distorted as a result of the radial offset between the spring 32 and the ridge 38, so that progressive throttling takes place up to a completely shut off position. The spring rate (of the spring 32), the stiffness of the plate 34 and the height of the ridge 38 can all be "tuned" in order to give the required cushioning.

The final limit of piston travel will be reached when the rebound spring 32 is fully compressed against its support 28.

Thus the spring 32 allows the stop plate 34 to close the apertures in the limit plate 26, whilst itself permitting a further small axial movement of the piston rod so that jarring is avoided when the piston reaches the end of its rebound stroke.

The embodiment shown in Figure 2 is very similar to that shown in Figure 1, but the rebound stop plate 34 is now supported by the piston guide 20, rather than by a separate rebound stop support 28. This gives a minimum 5 dead length, which can be used in a shock absorber which does not have to withstand any side loadings. Because the spring 32 is conical it can compress to a very small axial dimension.

Figure 4 shows an embodiment where the rebound stop support tube 28a is extended and is mechanically fixed against the piston rod guide 20. The upper end of the tube can be an interference fit in a groove in the lower face of the guide 20. This is an alternative way of securing the rebound spring 32, when a certain overlap between the piston rod 18 and the working cylinder 12 must be maintained in the full rebound position, to withstand the side

loads that are imposed by a Macpherson strut suspension linkage.

#### CLAIMS

1. A hydraulic shock absorber with a piston working in a cylinder, and a hydraulic rebound stop mechanism for limiting rebound travel of the piston, the mechanism comprising an annular rebound stop plate supported by a compression spring against the cylinder, the outer periphery of the plate being a close fit with the cylinder wall and the internal periphery of the plate being spaced from the piston rod, a piston travel limit plate secured to the piston, the piston travel limit plate having fluid flow apertures therethrough, and an annular ridge between the piston travel limit plate and the rebound stop plate, the stop plate and limit plate cooperating at one end of the piston travel in the cylinder so that the stop plate obstructs the fluid flow apertures in the limit plate, with the compression spring supporting the rebound stop plate around an annulus of different radius from that of the annular ridge on the piston travel limit plate and the rebound stop plate.
2. A shock absorber as claimed in Claim 1, wherein the annular ridge is on the piston travel limit plate.
3. A shock absorber as claimed in Claim 1, wherein the compression spring is fixed against one end of the working cylinder.
4. A shock absorber as claimed in Claim 3 or Claim 4, wherein the annular rebound stop plate is of nylon.
5. A shock absorber as claimed in any preceding claim, wherein the rebound stop plate and compression spring are clipped together.
6. A hydraulic shock absorber substantially as herein described with reference to any one embodiment shown in the accompanying drawings.